UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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August 31, 1999

Mr. Emil Klawitter (eeklawitter@efdnorth.navfac.navy.mil)
Northern Division, Naval Facilities Engineering Command
Code 1823/EK
10 Industrial Highway, Mailstop 82
Lester, PA 19113-2090

Re: ***EPA Supplemental Comments to the Draft 1998 Annual Monitoring Report for Sites 1, 3 and the Eastern Plume, Naval Air Station, Brunswick, Maine***

Dear Mr. Klawitter:

In the EPA's comment letter to the draft 1998 annual report we recommended geophysical investigations to address our concerns with the eastern plume. These concerns include:

- Possible migration flowpaths vs apparent stalling of the plume on the leading edges as detected in the current monitoring network.
- Potential bedrock exposure to the plume; past and/or current.
- Updating the conceptual model and synchronizing the GIS themes and USGS data.
- The possibility of DNAPL in the eastern plume that has been undetected to date and was discounted in the RI but that recent research indicates could be possible.

Attached, we provide more details and justification on the above concerns and detailed proposals for geophysical investigations which include:

- High resolution shallow seismic reflection.
- Penetrometer membrane interface probes.

We recommend this work be executed in a phased approach and follow-on work to be performed on the basis of results obtained; as such we have prioritize our recommendations. This would also best leverage the huge amount of data the Navy has already obtained from both the remedial investigation and long term monitoring program.

After you have evaluated our proposals and prior to your formal response, we propose technical meeting to discuss these issues and reach consensus on the best way forward. Because the figures that accompany this letter are about 10 megaytes I will only attach them in the hard copy. If you have any questions, please contact me at 617-918-1344 or barry.michael@epa.gov.

Sincerely,

MSBarry

Michael S. Barry
Remedial Project Manager
Federal Superfund Facilities Section

Attachment

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ATTACHMENT

Introduction

Completion of the review 1998 Annual Report, Monitoring Events 11 through 13, Sites 1 and 3 and Eastern Plume, at the Naval Air Station, Brunswick Maine; dated May 1999, and prepared by EA Engineering, Science, and Technology led to significant observations regarding the plume hydrogeology. This supplemental document includes further situation analysis and a table of recommended actions.

Conceptual Model Update

A more complete fracture trace analysis (Figure 1) was performed by identifying linear alignments of topographic sags, surficial drainage, bedrock depressions, top-of-clay depressions and elongate scouring in bedrock on both small and large-scales. Elongate scouring of bedrock was identified as 1) long, narrow submarine trenches, 2) long narrow marine bays, 3) saddles in bedrock-controlled topographic heights, and 4) short, elongate bedrock-controlled ravines and valleys.

The analysis used the surface water, bedrock, clay isopach and preliminary top-of-clay GIS themes for the Eastern Plume. These and other themes have apparent distortion relative to be available raster image of the USGS 1:24000 topographic map for Brunswick. This impacts the analysis, since the linears were defined using the distorted GIS themes and the rectified topographic map. The theme distortion varies by location, but typically amounts to a 100-150 ft. shift to the West in the areas of greatest interest. In spite of this, the uncorrected trace analysis presented in Figure 1 is sufficiently accurate for general planning purposes.

The further trace analysis suggests that the Merriconeag Stream valley is located at the convergence area of a radial pattern of multiple linears, with a general NE-SW orientation. There is some evidence, primarily hydrologic and topographic, that suggests that several sub-parallel NW-SE or W-E linears cross the valley as well. If this is true, then the Merriconeag Stream valley may have significant sub-vertical, primary and secondary fracture interconnection, reducing the possibility that bedrock contamination downgradient of Site 11 may flow significantly to the Southwest, along a fracture path. However, proof of high bedrock interconnectivity would not impact the possibility of an overburden preferential flowpath to the Southwest.

DNAPLs

The Record of Decision for the Eastern Plume states that the primary contaminants at Site 11 are DNAPLs, and consequently, residual contaminants may still exist at depth (U.S. Navy, 1998). Although other mechanisms exist and may be more likely, the apparent penetration of contamination into the clays at MW-331 (Figure 2), the plume flow to the Northeast, and the stalling of the southern leading-edge of the plume can all be explained by a DNAPL presence. However, DNAPLs were discounted in the remedial investigation on the basis of the industry's 10% of solubility limit guideline, 2D fate modeling and evidence that supported a capillary fringe source theory (U. S. Navy, 1992).

Contrary to this, a recently released study of chlorinated volatile organic compound plumes by Lawrence Livermore National Laboratory (U.S. EPA, 1999) notes that based on work by Newell and Ross, 1% of the solubility limit may be sufficient to infer the nearby presence of a DNAPL. The document further states that maximum concentrations ***suggest*** the presence of DNAPL in the majority of cases where a 1,000 ppb TCE plume may be defined. The areas of P106, MW-311, (and possibly P105, and MW-331) fall into this category (Table 1). It is feasible that DNAPLs could have exist undetected to date, given the difficulty of locating DNAPL pools with point investigation methods (penetrometer and drilling). The suggestion of DNAPL existence has a dual significance to the cleanup efforts in the Eastern Plume:

1) Due to equilibrium constraints, as dissolved DNAPLs are removed via cleanup activities, free phase constituents continue to partition into the dissolved phase. Therefore, it is critical to identify and address the free phase DNAPL zones located beneath the water table in order to achieve site remediation in a timely and cost-effective manner.

2) DNAPLs imply the existence of a cryptic plume situation, rather than a single overburden plume. If DNAPLs existed at Site11, they may have remained in the overburden, but flowed in a different direction from the dissolved phase, or pooled in local minima, and 2 plumes would exist. Alternatively, DNAPLs may largely been stripped off where the groundwater plume crossed bedrock/coarse-sand, just downgradient from Site 11 (Figure 3). While this might explain the relatively low VOC concentrations observed in the overburden plume, but it would also imply the possibility of 4 plumes:

    1) the current overburden dissolved-phase plume
    2) an overburden DNAPL plume
    3) a bedrock dissolved phase plume
    4) a bedrock DNAPL plume.

Recommendations

Figure 1 demonstrates that five areas of the Eastern Plume have separate investigative needs.

- Area 1 needs to be investigated to determine the spatial extent of the near-source No-Clay zone and the possibility of bedrock contamination (Figure 3).
- Area 2 needs to be investigated to more clearly determine reasons for the deep flow Northeast of the source area, for the possible role of the apparent underlying convergence of linears, and for the possible existence of DNAPLs.
- Area 3 encompasses a local minimum in the top-of-clay surface that needs to be defined spatially, and tested for the existence of DNAPLs.
- Area 4 encompasses recently developed well MW-331, which is located in an apparent bedrock depression, and has registered electrical conductivity values 5-10 times that of other Eastern Plume wells. The spatial extents of this bedrock depression, and possible

paleochannels or preferential flowpaths need to be defined, followed with testing for DNAPLs.

- Area 5, at the southern termination of the plume needs investigation to explain the apparent lack of progress of the plume over time, and to assess whether the entire plume is being captured by extraction efforts. Possible explanations for the plume behavior include flow to surface waters (currently under investigation), an undetected preferential groundwater flowpath or paleochannel in the overburden to the Southwest; and DNAPL pooling or flow in the overburden. These explanations for plume behavior have varying probabilities, but none can be ruled out given current knowledge.

Table 2 contains recommendations and the rationale for the next phase of addressing these questions. Many of the recommendations place an emphasis on the use of a number of cutting-edge technologies, especially high-resolution shallow seismic reflection. Due to their leading-edge nature, a brief discussion of these technologies is included below.

High Resolution Shallow Seismic Reflection

Considering the depth of the geologic strata of the Eastern Plume, the greatest profiling success is likely to result from seismic refraction, stationary EM methods, or seismic reflection, which has only been developed as a practical tool for shallow (2-100 m) investigations over the past 10-15 years. Reflection is most expensive of the three. However, the greater expense is compensated for by greater data intensity per station.

The success of high-resolution shallow seismic reflection is very site dependent. This technique can be impacted by ground roll (undesired surficial Rayleigh waves), and works best in relatively flat terrain, with compacted (rather than loose) surficial materials, and a near surface water table. Success is also sensitive to the specific energy source used. In the Eastern Plume, high-resolution shallow seismic reflection can be expected to profile the bedrock/clay interface, the clay/coarse sand interface, possibly the transition zone boundaries, which are less distinct. With special consideration, buried paleochannels, narrow sedimetary layers, fractures in bedrock, fractures in clay (NELPS Fact Sheet No. 6), and significant DNAPL pools may be able to be detected (Waddell, 1999). Pre-study modeling can help improve the accuracy by identifying frequencies and techniques needed to capture these features.

2D cross sections can provide the first level analysis. These can be used to determine areas of special interest (e.g. to identify local top-of-clay minima that may capture DNAPL) that would benefit from 3-D reflection techniques. In the vicinity of MW-331, where the plume is associated with a high electrical conductivity, stationary electromagnetic surveying (depths 7.5 - 60 m) may be a low cost alternative.

HydroSource of Ashland, NH and Geophysics GPR International of Needham Heights, MA are 2 firms that would be able to provide shallow seismic reflection services.

Penetrometer Membrane Interface Probe

Subsequent verification of reflection-determined preferential flowpaths, paleochannels, and DNAPL pools can be carried out by direct push studies as before. A possible cost-saving alternative may be available through the Site Characterization and Analysis Penetrometer System (SCAPS). SCAPS is a tri-service research, development, and technology demonstration program, with the U.S. Army Environmental Center as the lead. It combines traditional cone penetrometer technology with cutting-edge contaminant sensors and samplers to quickly and inexpensively provide a profile of contaminants and geophysical properties at hazardous waste sites. John Ballard, a SCAPS program manager, indicated that a prototype Membrane Interface Probe (MIP) has been developed which can sample contamination at multiple depths fairly quickly, without having to withdraw the probe. This technology may be available for use at Brunswick Naval Air Station through partnering on a reimbursable basis, given that the site is government-owned, the technology has yet to be released to the public, and the SCAPS researchers are interested in proving the technology at multiple sites (John Ballard, Corps of Engineers, SCAPS Program, Vicksburg, MI, personal communication). According to Mr. Ballard, this possibility can be explored with Bill Davis, program manager for MIP effort at the Engineering Research and Development Section, in the Vicksburg, MI office of the Corps of Engineers (601-634-3786). General information on the SCAPS program can be found on internet at http://www.scaps.com.

Monitored Natural Attenuation

Finally, is suggested that this and all future work efforts be structured to satisfy the site characterization requirements of the EPA technical protocol for monitored natural attenuation. Given the complexity of the Eastern Plume and the difficulty of wholly remediating the site, planning for monitored natural attenuation may make long-term economic sense. Note that the recommendations of this document, if carried out, will involve significant further characterization of the site, and may lead to a more complete three-dimensional conceptual model, as required for a monitored natural attenuation program.

References

Navy Environmental Leadership Program (NELP), NELP Fact Sheet No. 6, 2D and 3D High-resolution Seismic Reflection Surveys to Image the Subsurface, September 1996.
(Available in pdf format at http://www.nasni.navy.mil/~nelp/)

Naval Facilities Engineering Service Center, Ongoing Project Description: High-resolution 3-D Geophysical Surveys (Seismic Reflection and Electromagnetic Resistivity) for Locating Subsurface DNAPL Contamination. (http://www.nefsc.navy.mil/enviro/ps/3d)

U.S. EPA, Technical Protocol for Evaluating Natural Attenuation Of Chlorinated Solvents in Groundwater, Office Of Research and Development, Washington DC, September 1998.

U.S. EPA, Lawrence Livermore National Laboratory, Historical Case Analysis Of Chlorinated Volatile Organic Compound Plumes, March, 1999, p. 13.

Waddell, Michael G., Earth Sciences and Resources Institute, USC, Columbia, SC; Tom J. Temples, Department of Energy, Savannah River Site; Aiken, SC; Using High-Resolution Reflection Seismic To Image Free Phase DNAPLs At the M-Area, Savannah River Site; Research Abstract.

(http://www.esri.sc.edu/facilities/SEISMIC/AAPGDNAP.htm)

EVENT	LOCATION	PARAMETER	VALUE	UNITS
Event 11	MW-311	1,1,1-Trichloroethane	**14000**	ug/L
Event 9	MW-311	1,1,1-Trichloroethane	11000	ug/L
Event 9	MW-311	1,1,1-Trichloroethane	11000	ug/L
Event 4	MW-311	1,1,1-Trichloroethane	11000	ug/L
Event 6	MW-311	1,1,1-Trichloroethane	11000	ug/L
Event 6	MW-311	1,1,1-Trichloroethane	10000	ug/L
Event 3	MW-311	1,1,1-Trichloroethane	9800	ug/L
Event 6	MW-311	1,1,1-Trichloroethane	9600	ug/L
Event 2	MW-311	1,1,1-Trichloroethane	7100	ug/L
Event 10	MW-311	1,1,1-Trichloroethane	6100	ug/L
Event 10	MW-311	1,1,1-Trichloroethane	5800	ug/L
Event 6	P-106	1,1,1-Trichloroethane	4500	ug/L
Event 5	P-106	1,1,1-Trichloroethane	4100	ug/L
Event 12	MW-311	1,1,1-Trichloroethane	3700	UG/L
Event 12	MW-311	1,1,1-Trichloroethane	3700	UG/L
Event 7	MW-311	1,1,1-Trichloroethane	3500	ug/L
Event 3	P-106	1,1,1-Trichloroethane	3500	ug/L
Event 13	MW-311	1,1,1-Trichloroethane	3400	ug/L
Event 1	P-105	1,1,1-Trichloroethane	3300	ug/L
Event 3	P-105	1,1,1-Trichloroethane	3100	ug/L
Event 13	P-106	1,1,1-Trichloroethane	2900	ug/L
Event 10	P-106	1,1,1-Trichloroethane	2300	ug/L
Event 11	P-106	1,1,1-Trichloroethane	2200	ug/L
Event 5	P-105	1,1,1-Trichloroethane	2100	ug/L
Event 9	P-106	1,1,1-Trichloroethane	2100	ug/L
Event 12	P-106	1,1,1-Trichloroethane	2000	ug/L
Event 7	P-106	1,1,1-Trichloroethane	1900	ug/L
Event 11	P-105	1,1,1-Trichloroethane	1900	ug/L
Event 13	EW-02A	1,1,1-Trichloroethane	1800	ug/L
Event 9	P-105	1,1,1-Trichloroethane	1700	ug/L
Event 10	P-105	1,1,1-Trichloroethane	1600	ug/L
Event 6	P-105	1,1,1-Trichloroethane	1400	ug/L
Event 12	P-105	1,1,1-Trichloroethane	1100	ug/L
Event 13	MW-331	1,1,1-Trichloroethane	1000	ug/L
Event 3	EW-4	1,1,1-Trichloroethane	1000	ug/L
Event 4	MW-306	1,1,1-Trichloroethane	1000	ug/L
Event 11	MW-311	Trichloroethene	3400	ug/L
Event 9	MW-311	Trichloroethene	2800	ug/L
Event 4	MW-311	Trichloroethene	2800	ug/L
Event 6	MW-311	Trichloroethene	2700	ug/L
Event 3	MW-311	Trichloroethene	2500	ug/L
Event 2	MW-311	Trichloroethene	1600	ug/L
Event 6	P-106	Trichloroethene	1300	ug/L
Event 10	MW-311	Trichloroethene	1300	ug/L
Event 7	MW-311	Trichloroethene	1200	ug/L
Event 5	P-106	Trichloroethene	1100	ug/L
Event 3	P-106	Trichloroethene	1000	ug/L

Table 1. 1,1,1-TCA and TCE samples > 1000 ug/L . A 1% limit equates to 12,500-14,950 ug/L for 1,1,1-TCA, and 11,000 ug/L for TCE.

Area	Recommended Action	Rationale	Priority
NA	1) Rectify GIS themes to USGS topographic map. 2) Generate Top-of-Clay contour theme. 3) Modify preliminary fracture trace analysis.	Accurate geo-referencing of Top-of-Clay, Bedrock, and Clay Isopach themes is essential to correct placement of linears, and pre-study modeling efforts.	1
Area 5 Area 4 Area 3 Area 2	1) Perform high resolution 2D shallow seismic reflection survey. Use pre-study modeling to optimize survey results.	To profile sedimentary strata and bedrock. To identify possible preferential flowpaths, paleochannels, fractures and local minima. To identify possible large DNAPL pools.	Area 5: 2 Area 4: 4 Area 3: 5 Area 2: 6 (See comment at end of table)
	2) Use the survey results to guidea direct push study, using a MIP probe, if possible.	To verfiy sedimentary strata. To sample for contamination, including DNAPLs.	
	3) On the basis of the 2D survey and direct push study, evaluate need for a high resolution 3D shallow seismic reflection survey, and perform ,if necessary. Stationary EM methods may suffice for Area 4 (near MW-331)	To refine the possible locations of local minima and/or possible large DNAPL pools.	
In addition for Area 5	1) Identify Southern plume behavior 2) Plan further investigation if necessary.	To resolve whether overburden plume or plumes have been fully addressed.	
In addition for Area 2	1) Install nested overburden/bedrock piezometers if necessary.	To refine deep flow gradients, if unusual stratigraphy is found.	
Subsequently for all Areas, including Area 1	1) If DNAPL is identified, plan and implement removal	For timely and cost effecient plume cleanup.	
	2) If DNAPL is not identified, re-evaluate and modify the extraction system in light of findings, if necessary.	For timely and cost effecient plume cleanup.	

Table 2, Part I of II. Recommendations for Supplemental Investigation

Area	Recommended Action	Rationale	Priority
Area 1	1) Perform high resolution 2D shallow seismic reflection survey.	To evaluate the potential for bedrock contamination. By defining the spatial extent of bedrock ridge, the extent of the coarse sand/bedrock interface, possible primary fractures, possible DNAPL flowpaths both East and West of the bedrock ridge.	Area 1: 3
	2) Perform a 3D high resolution shallow seismic reflection survey if necessary.	To further refine possible overburden DNAPL flowpaths.	
	3) If historic bedrock contamination appears possible, install overburden/bedrock piezometer nests based on reflection and resistivity results.	To define vertical hydraulic gradients and evaluate possibility of dissolved phase bedrock contamination, with or without DNAPL.	
	4) If historic bedrock contamination appears possible, utilize survey results to develop assessment campaign involving resistivity fracture assessment and borehole flow analysis.	To further assess fracture orientation, and the possibility of contamination having reached the major clay-linears.	
MW-311 P-106 MW-331 P-105	1) Test for DNAPLs using electro-optic sensor, or other standard method.	Easiest, least expensive approach to verify DNAPL presence.	7

Comments on Prioritization:
GIS correction is first due to need for modeling in subsequent steps.
Area 5 is second due to plume termination enigma and the high possibility of DNAPL detection.
Area 1 is third given that some bedrock exposure must have occurred, the significant ramifications that could result, and a need to act early. Area 4 is fourth due to the value of identifying preferential flowpaths in the vicinity, and given high possibility of DNAPL detection.
Area 3 is fifth given the high possibility of DNAPL detection.
Area 2 is sixth since the flow mechanism is not fully clear, and DNAPLs may exist, but EW-5 is possibly controlling the situation.
Testing for DNAPLs at highly contaminated wells is seventh since such testing would not rule out the current existence of DNAPLs, and further testing would still be required.
Note that if no DNAPL is found in areas of greater priority, 3D methods become less necessary for subsequent areas.

Table 2, Part II of II. Recommendations for Supplemental Investigation

Figures

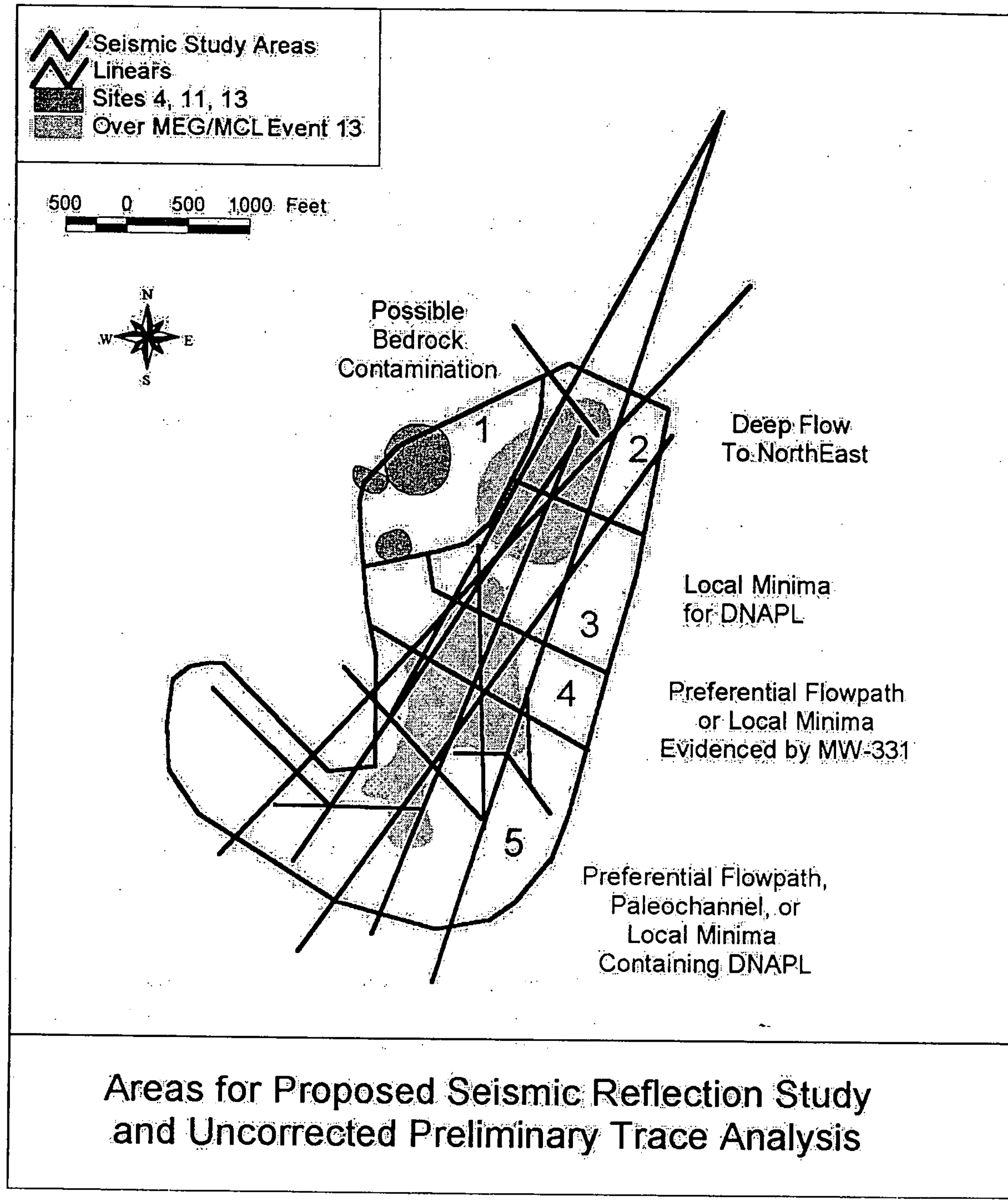

Figure 1. Proposed seismic reflection study areas and the uncorrected preliminary trace analysis. The primary rationale for each of study area is presented next to it. The linears have no proven geologic significance as yet. However, some likely reflect glacially-scoured bedrock fractures, and depressions associated with fracture intersections. Such features can be expected to play key roles in bedrock groundwater flow. With regard to the known overburden plume, bedrock depressions will be reflected in the top-of-clay surface, and may correlate to paleochannels, preferential flowpaths or local minima at the top-of-clay/coarse sand interface. DNAPLs existing in local overburden pools would continue to release dissolved phase material to groundwater.

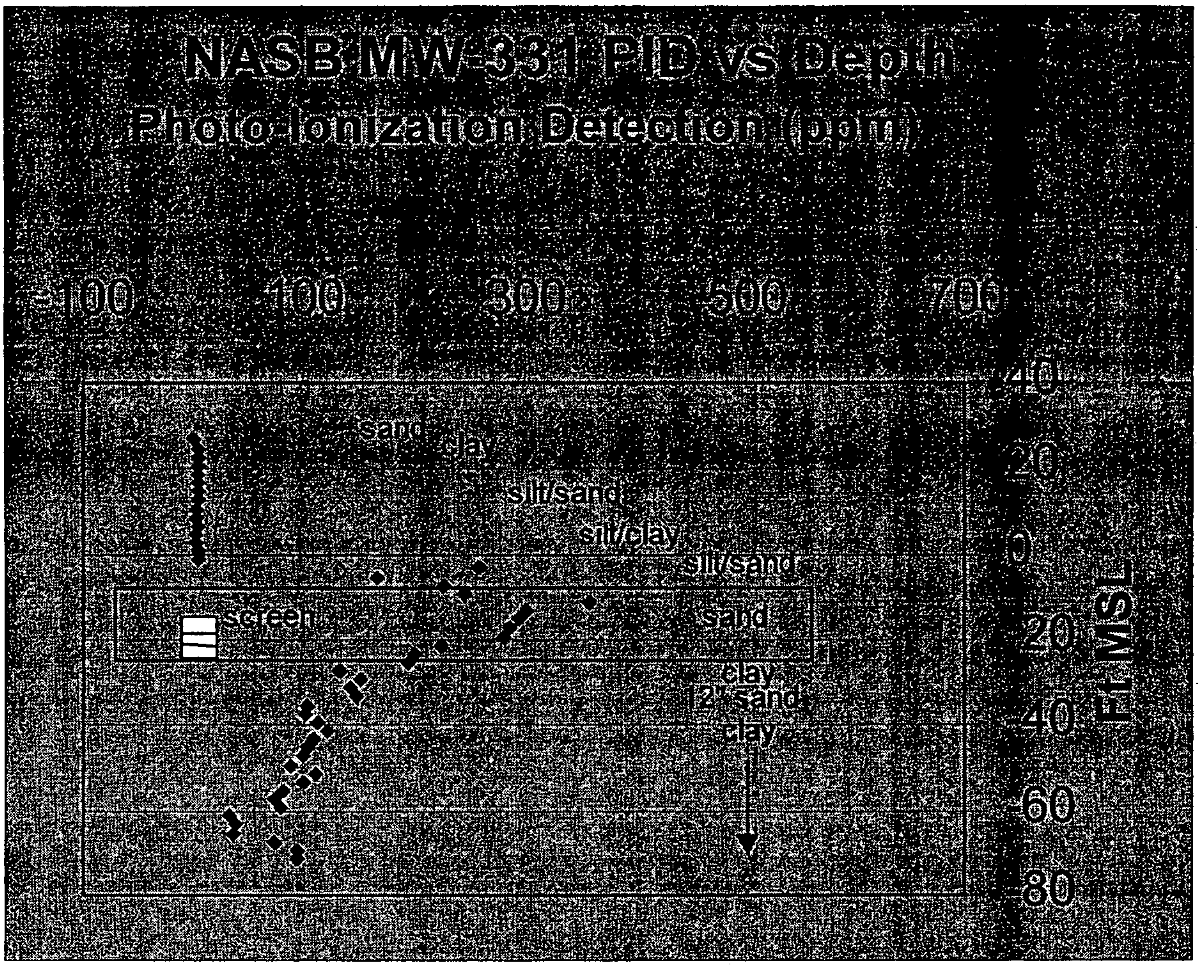

Figure 2. The Photo-Ionization readings taken from soil samples during construction of MW-331, which registered 1546 ug/L Total VOC during Event 13. Some penetration into the underlying clay was indicated. This suggests vertical groundwater flow downward, possible DNAPL migration, or surficial adsorption to the underlying clay. The vertical flow component is likely up in this circumstance.

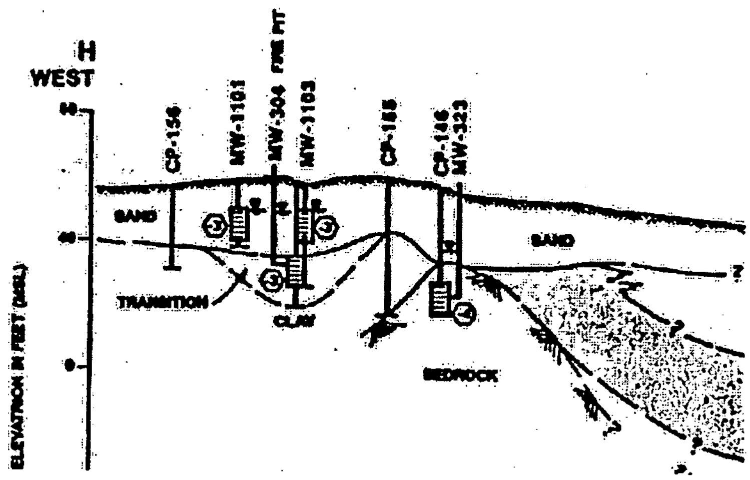

Figure 3. A vertical cross-section of the shallow no-clay zone immediately downgradient of the source area as depicted in Figure 8-8 of the 1991 E.C. Jordan study. DNAPLs were not observed in the source area, and contamination levels in the bedrock well were low. However, the Record of Decision notes DNAPLs may still exist at depth. If DNAPLs existed in the past, they may have been able to reach bedrock downgradient of the source area., and separated from the dissolved phase at that point. Alternatively, they may have been contained by the clay and moved North, remaining to the West of the bedrock ridge.